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Managing Asset Integrity Risk by Integration of Integrity Operating Windows (IOW)

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Introduction

An integrity operating window (IOW) program involves the identification, measurement, and analysis of the parameters necessary to control the process within the established limits of an asset integrity management (AIM) program. At a minimum, IOW programs help operators know when, for how long, and by how much the established limits were violated. By implementing an effective IOW program, a company can control potential damage to process equipment and recognize changes to the process that may affect the values used in the development of the AIM program. When deviations from safe operating limits are quickly recognized, efforts can be immediately implemented to return the process to within the integrity operating window. The need for additional or different inspection and testing can also be identified and executed to ensure the equipment continues to operate within safe limits.

An IOW is defined as "Established limits for process variables (parameters) that can affect the integrity of the equipment if the process operation deviates from the established limits for a predetermined length of time (includes critical, standard, and informational IOWs)" per API 584, *Integrity Operating Windows, 1st ed., 2014*. The purpose of an IOW program is to establish, implement, and maintain a program for the identification of extraordinary events that can lead to potential damage mechanisms exceeding safe operating limits with the express purpose of avoiding equipment degradation leading to a loss of process containment.

Developing the Program

Integrity operating windows serve as a critical tool for ensuring the safety of personnel, facilities, and the surrounding environment. Organizations can minimize the risk of incidents, accidents, and environmental harm by establishing clear boundaries for safe operation.

Damage Mechanism Review

The first step in developing an IOW program is to perform a damage mechanism review (DMR). This analysis should be performed by qualified and experienced personnel including both IOW subject matter experts (SMEs) and plant personnel to document all possible damage mechanisms that may adversely impact the equipment due to the operating parameters and material of construction.

It is critical to understand all the potential damage that can credibly occur when an IOW limit is exceeded. Each DMR should identify all potential, credible damage mechanisms, evaluate the materials of construction for affected assets, and develop a damage/corrosion map that can assist greatly once the piping and instrumentation diagram (P&ID) review takes place. Then you must define the limits for each damage mechanism, such as pressure, temperature, pH acidity/alkalinity, water content, etc.

Risk Ranking

Following the DMR, perform comprehensive risk assessments to identify potential hazards, failure modes, and consequences associated with each asset or process. Consider factors such as operational conditions, environmental factors, human factors, and regulatory requirements. The consequence of failure is critical to risk rank your assets.

After risk ranking all assets involved with the process being evaluated, evaluate the needs for alarms and alerts necessary to recognize IOW exceedance. The evaluation process requires that you determine the criticality of the operating limit and define the priority of the IOW limits.

An IOW can be categorized as:

Critical IOW – Alarm requiring an operator's or SME's timely response to bring the process back within the integrity operating window.

Standard IOW – Typically includes an alert to operations personnel and the Reliability SME. Standard IOWs usually have a time frame associated with them. If an integrity limit is exceeded for a set time, equipment will suffer damage.

Informational IOW – Information conveyed from field gathered data to the Reliability SME. This information may require changes to the risk-based inspection (RBI) assumptions, frequency of inspection, or nondestructive evaluation (NDE) methodology considerations.

Define the integrity operating limit and the parameters that should control the IOW such as high Cl concentration, minimum H_2O concentration, high temperature or low temperature, and high pH or low pH.

Establishing the IOWs

Once you have determined the criticality of each IOW, the SME should review all the existing instruments noted on the P&ID so existing instruments that give the appropriate information can be designated as the indicator for the IOW. If there are no existing instruments that provide the data required, new instruments shall be designated for installation.

Based on the risk assessments and critical parameter identification, establish clear integrity operating windows for each asset or

System	Description	Color		API 570 Pipe Class	Damage Mechanism	Limits	Damage Mechanism	Limits	Damage Mechanism	Limits	Damage Mechanism	Limits
100	Ammonia	Orange		Class 1	NH3 SCC	Carbon steel in aqueous ammonia Non-PWHT	Ammonium Chloride Corrosion	Concentration of ammonium chloride salts and temperature	Chloride SCC	300 Series stainless steel concentration of chlorides and temperature	CUI	Insulated piping or vessels that are intermittent or operate between: 10°F-350°F
101	Ammonia Refrigerant	Orange	Purple	Class 1	NH3 SCC	Carbon steel in aqueous ammonia Non-PWHT	Ammonium Chloride Corrosion	Concentration of ammonium chloride salts and temperature	Chloride SCC	300 Series stainless steel concentration of chlorides and temperature	CUI	Insulated piping or vessels that are intermittent or operate between: 10°F-350°F
200	Acid Gas	Orange	Red	Class 1	Wet H2s Damages	Carbon and low alloy steels PWHT-SOHIC & SSC					CUI	Insulated piping or vessels that are intermittent or operate between: 10°F-350°F
300	Recycle Gas	Pink	Red	Class 2	Wet H2s Damages	Carbon and low alloy steels PWHT-SOHIC & SSC					CUI	Insulated piping or vessels that are intermittent or operate between: 10°F-350°F
301	Sweet Syngas	Green	Light Blue	Class 2	Wet H2s Damages	Carbon and low alloy steels PWHT-SOHIC & SSC					CUI	Insulated piping or vessels that are intermittent or operate between: 10°F-350°F

Figure 1. System classification with damage mechanism ID'd and limits noted.

process. Define the acceptable operating ranges and conditions within which equipment and processes must operate to ensure safety, reliability, and regulatory compliance.

Implement robust, well-calibrated monitoring and control systems to continuously monitor the critical parameters and detect deviations from the integrity operating windows in real time. Utilize sensors, instrumentation, control systems, and data analytics to provide early warnings of potential issues and enable timely interventions.

Develop standardized procedures and protocols for responding to IOW excursions. Define roles and responsibilities, escalation paths, and corrective actions to be taken in the event of a deviation from the acceptable operating range.

Training Responsible Personnel

Provide comprehensive training for operators, maintenance personnel, and other relevant staff on the importance of integrity operating windows, as well as the procedures for monitoring, controlling, and responding to deviations. Ensure that personnel understand their roles and responsibilities in maintaining asset integrity and safety.

In a dynamic operating environment, it's essential to remain agile and adaptive. Be prepared to update and adjust IOWs in response to changes in operating conditions, technology advancements, regulatory requirements, or lessons learned from incidents or near-misses.

Stay Agile and Adaptive

In a dynamic operating environment, it's essential to remain agile and adaptive. Be prepared to update and adjust IOWs in response to changes in operating conditions, technology advancements,

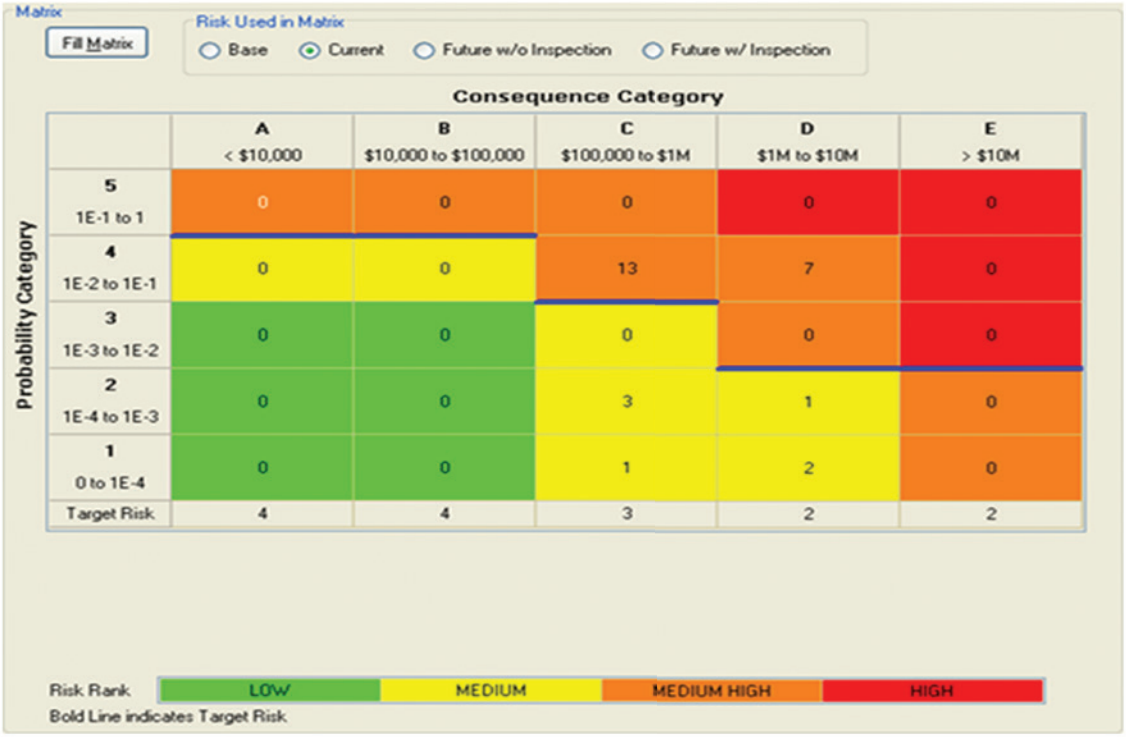

Figure 2. Example risk-rank evaluation noting criticality categories

regulatory requirements, or lessons learned from incidents or near-misses.

IOW Integration

Integrity operating windows must be integrated into the other Reliability and operational programs in the facility. IOWs should be integrated into the comprehensive mechanical integrity (MI) program, the RBI program, as well as operations and engineering. IOWs should be revalidated on a set frequency to test validity and integration into the plant operations.

Auditing

An audit should be performed at least every three years, and this may be performed as part of the PSM three-year MI audit.

Conclusion

In conclusion, integrity operating windows play a vital role in safeguarding industrial assets, protecting personnel, and ensuring regulatory compliance. By defining clear boundaries for safe operation and risk management, IOWs help organizations mitigate risks, enhance safety, protect assets, and optimize operational efficiency.

Implementing and adhering to integrity operating windows require a comprehensive understanding of equipment design, operating conditions, risk assessment, monitoring systems, and continuous improvement practices. By integrating IOWs into their operational framework, organizations can enhance reliability, safety, and sustainability while minimizing operational risks and maximizing the value of their assets. ■

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For nearly 30 years, Russ has worked in asset integrity program development and implementation. His experience includes pressure vessels, aboveground storage tanks (AST), piping inspection, testing and evaluation, and process safety management (PSM). He has developed and directed asset integrity programs for a global chemical company with facilities in North America, South America, Europe, and Asia Pacific regions. Russ has served as an owner-operator and external consultant for the implementation of asset integrity programs. He has knowledge of NDE, damage mechanisms, and the various materials of construction for equipment in the refining, chemical, and energy industries.